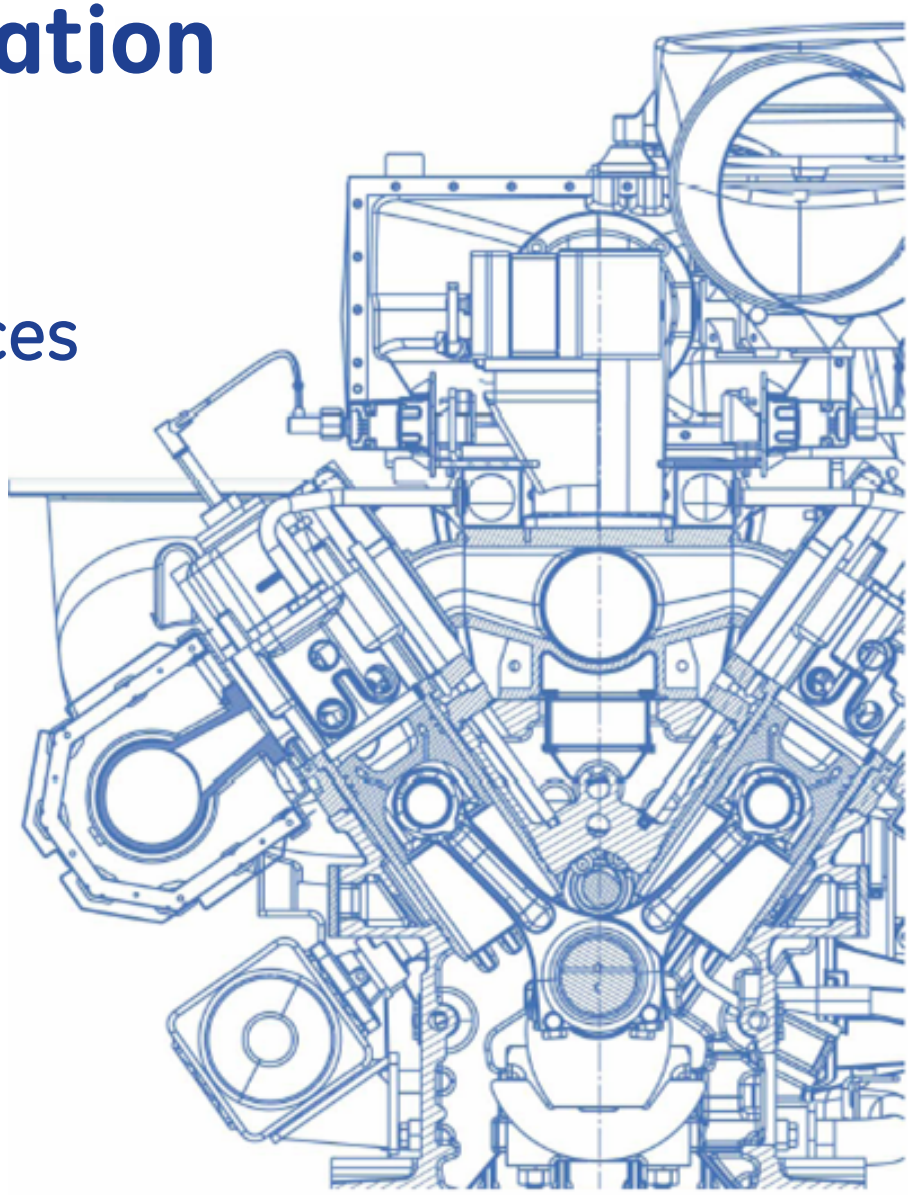
Power Generation from Biomass Gasification with Gas Engines -

Requirements and Experiences



Martin Schneider
GE - Jenbacher gas engines
Austria

GE imagination at work

Jenbacher gas engines – Overview

A leading manufacturer of gas-fueled reciprocating engines for power generation.

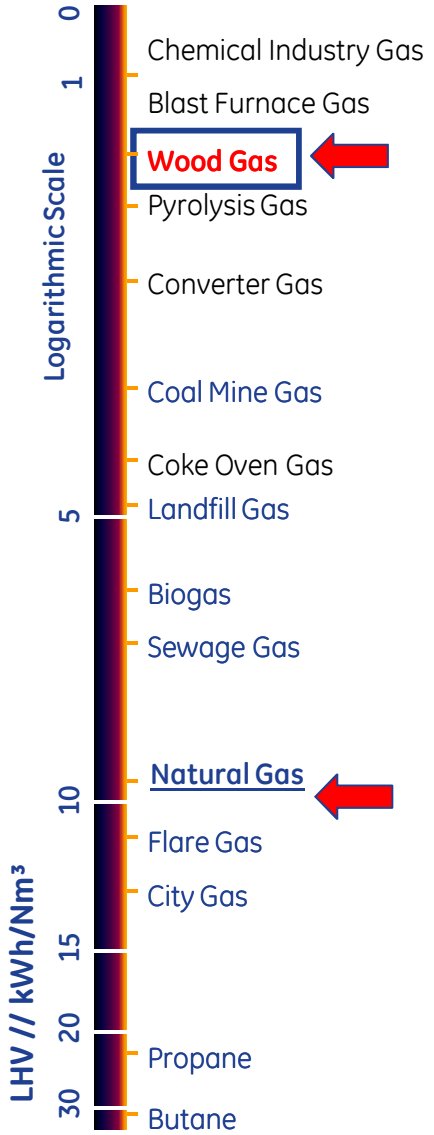
- Power range from 0.25MW to 3MW, 4 platforms / 10 products
- Fuel flexibility: Natural gas or a variety of renewable or alternative gases (e.g., landfill gas, biogas, coal mine gas)
- Plant configurations: Generator sets, cogeneration systems, container solutions
- Delivered engines: about 8,000 units / 9,000 MW

Fuel Flexibility with Jenbacher Engines

Natural Gas,
Propane,
LNG, ...

Landfill Gas
Biogas
Coal Mine Methane

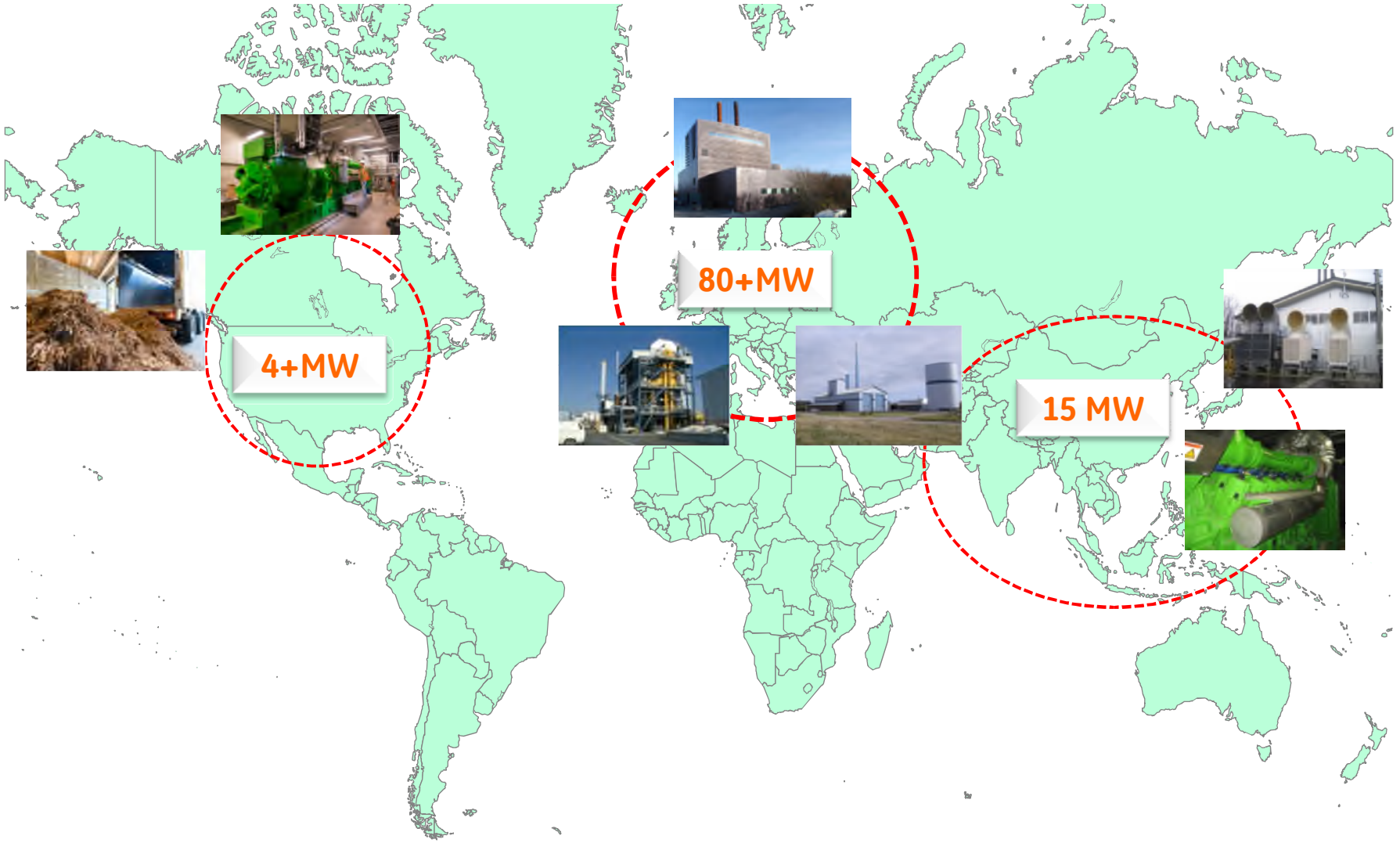
Special Gases
(COG, BFG, LDG, Wood gas, ...)



Important fuel properties to consider

- ✓Heating Value
- ✓Methane Number
- ✓Laminar Flame Speed

Biomass/Woodgas references



...almost 100 MWe installed; ...majority in Europe

Experiences with Wood gasification

- Harboore / Denmark;

  Woodgas; H_2: 15 - 18%; CO: 25-28%; LHV = 6.8 MJ/Nm³

- Güssing / Austria

  Woodgas; H_2: 35 - 40%; CO: 20-25%; LHV = 10.5 MJ/Nm³

- Stans / Switzerland

  Woodgas; H2: 12 - 15 %; CO: 18-20%; LHV = 5.4 MJ/Nm³

- Skive / Denmark

  Woodgas; H2: 15 - 18%; CO: 18 - 20%; LHV = 6.1 MJ/Nm³

- Molla / Spain

  Woodgas; H2: 12 - 15%; CO: 15 - 17%; LHV = 5.1 MJ/Nm³

Main data of successful operating wood gas plants (extract)

Plant	Harboøre/Dk	Nidwalden/CH	Güssing/A
Gasifier Supplier	Babcock & Wilcox Vølund	Pyroforce	Repotec
Gasifier concept	Fixed bed - updraft	Fixed bed - downdraft	Fluidized bed steam gasifier
Engine	2 x J320	2 x J320	1 x J620
Electrical outut	2 x 765 kWe	2 x 600 kWe	1 x 1960 kWe
Commissioning	3/2000	4/2001	4/2002
operating hours *)	> 105,000 oph (total)	> 30,000 h (total)	> 50,000 oph
Gas cleaning technology	wet-electrostatic filter + integrated scrubber	precoat filter; gas scrubber	precoat filter; gas scrubber (RME)

*) 09/2012

..... ~ 80 engines / 100 MW installed

15+ different gasification concepts

total > 300,000 oph accumulated experience

Biomass Gasification Harboøre/Dk

Harboøre/Denmark
2 x JMS 320 GS S.L

Concept:
Fixed bed updraft
from B&W Vølund

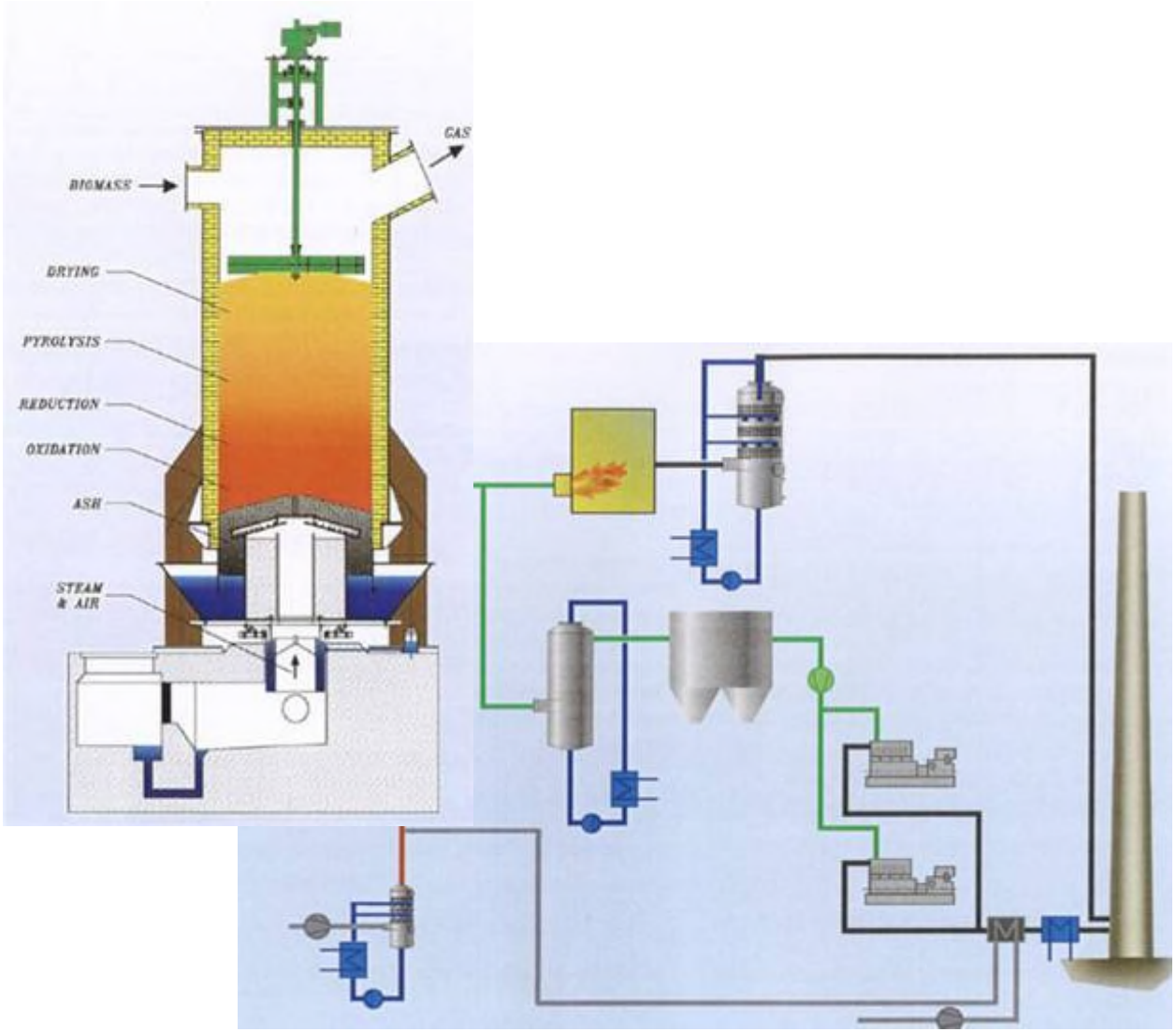
2 x J320
2 x 760 kWe

wood gas:

H_2	15 - 18%
CH_4	3 - 5%
CO	25 - 28%
CO_2	7 - 10%
N_2	50 - 55%
LHV	6.8 MJ/Nm³

...more than 105,000 ophs (09/2012), ...increased output (bmep = 13bar) since 04/2001

Biomass Gasification Harboøre/Dk



Harboøre/Denmark

Concept:
Fixed bed updraft
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wood gas:

H_2	15 - 18%
CH_4	3 - 5%
CO	25 - 28%
CO_2	7 - 10%
N_2	50 - 55%
LHV	6.8 MJ/Nm³

2 x J320
2 x 760 kWe

Biomass gasification Tohoku-Yamagata/Jp

Yamagata/Jp

Fixed bed updraft
JFE/Babcock-Vølund

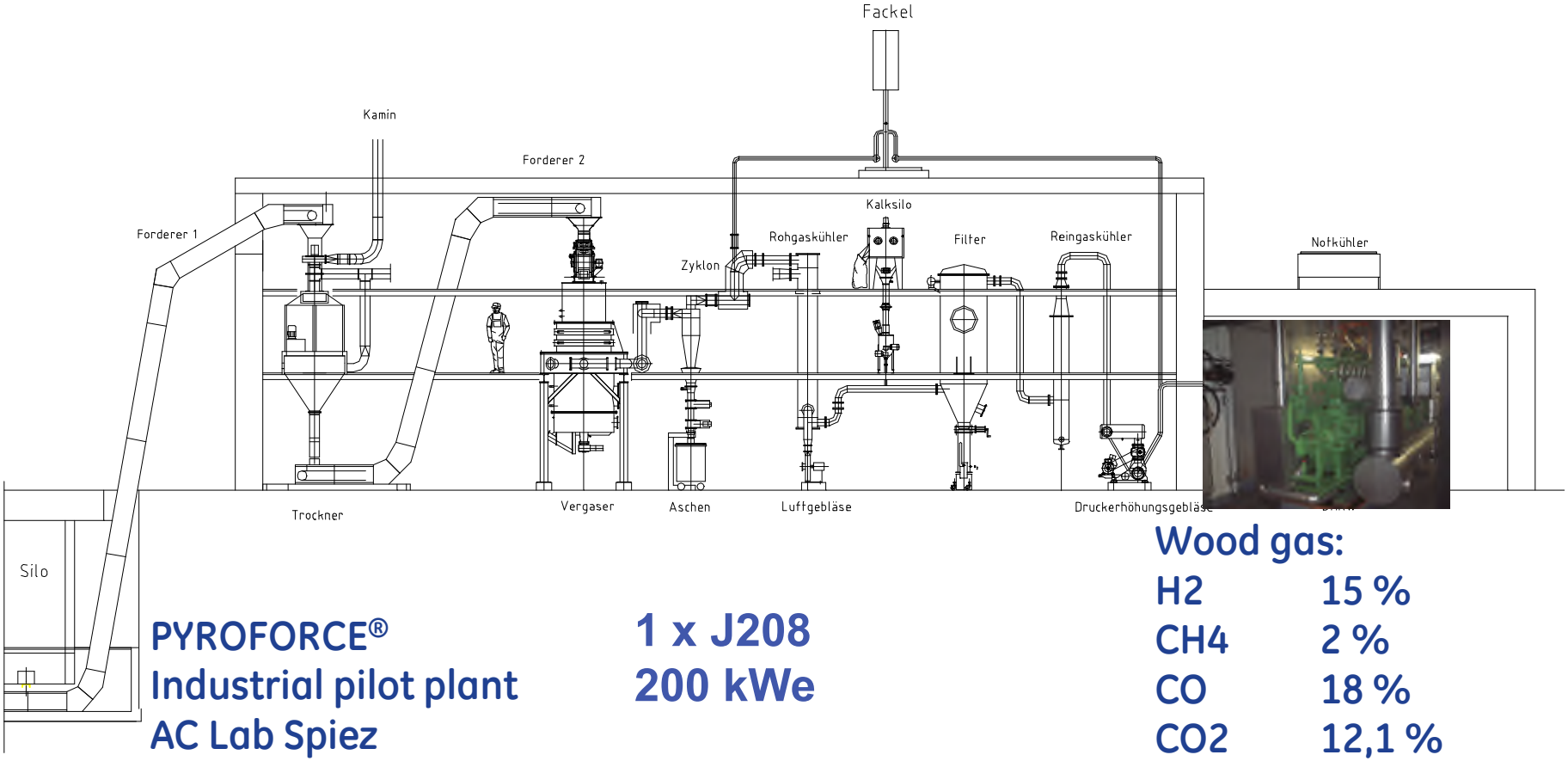
Wood gas:

H_2	15 - 18%
CH_4	3 - 5%
CO	25 - 28%
CO_2	7 - 10%
N_2	50 - 55%
Hu	6.84 MJ/Nm³

1 x J612/1 x J616
900kWe / 1200kWe

...~15,000 ophs (12/'09); ...JFE/Backcock Vølund® ...commissioning 2007

Biomass gasification Spiez/CH



PYROFORCE®
Industrial pilot plant
AC Lab Spiez
Concept:
Fixed bed downdraft

1 x J208
200 kWe

Wood gas:

H2	15 %
CH4	2 %
CO	18 %
CO2	12,1 %
N2	47,1 %
H2O	rest
LHV	5.4 MJ/Nm³

...~15,000 ophs .... PYROFORCE® pilot lant

Pyroforce® – further commercial projects

Biomass power plant Nidwalden/CH

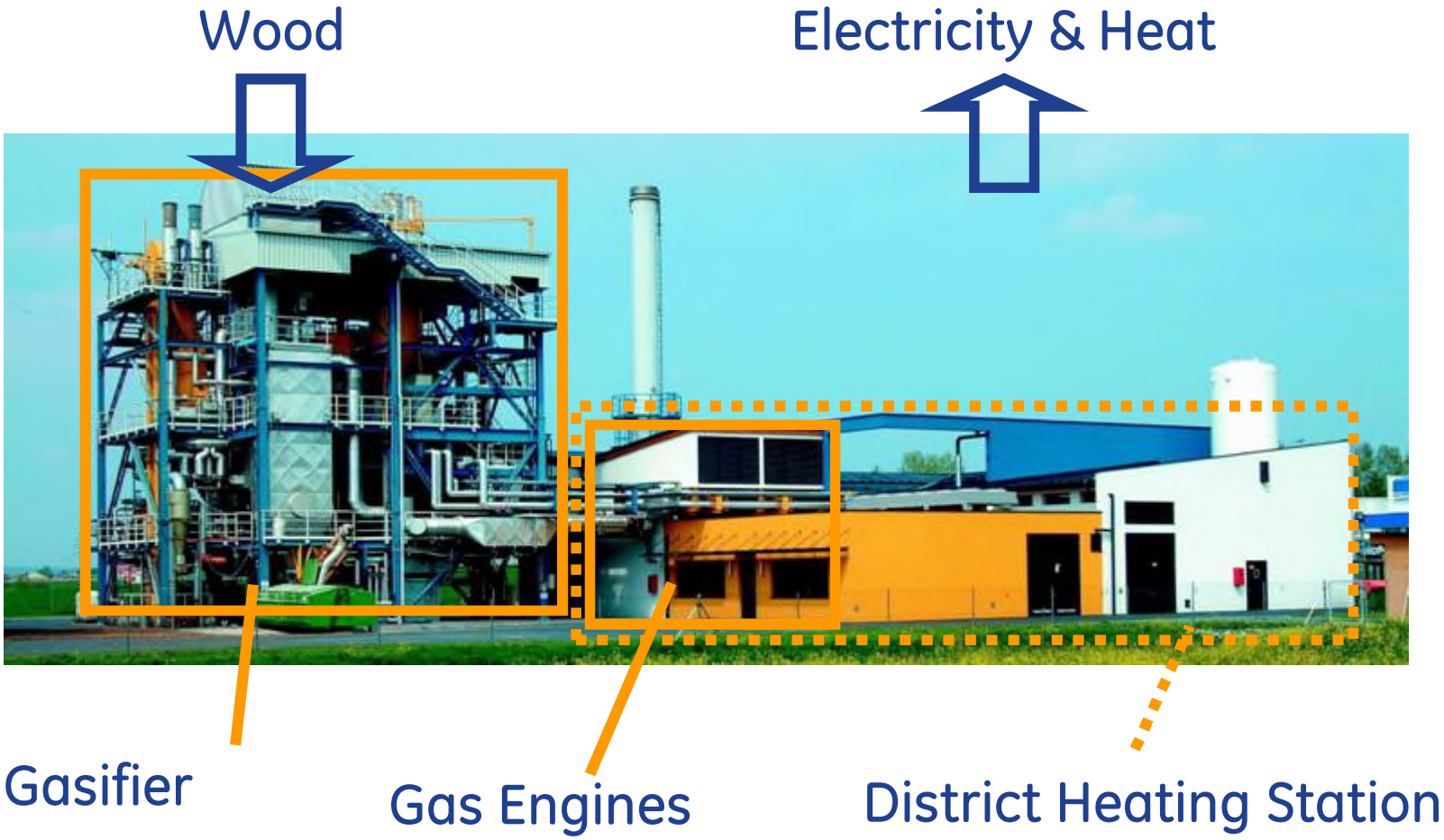
2 x J320
2 x 600 kWe

Biomass plant Güssing 2 /AUT

1 x J312
1 x 345 kWe

...Nidwalden~15,000 ophs (07/'12); ...PYROFORCE® ...commissioning 2007

Biomass Gasification Güssing/A



Biomass Gasification Güssing/A

Concept:
fluidized bed steam gasification

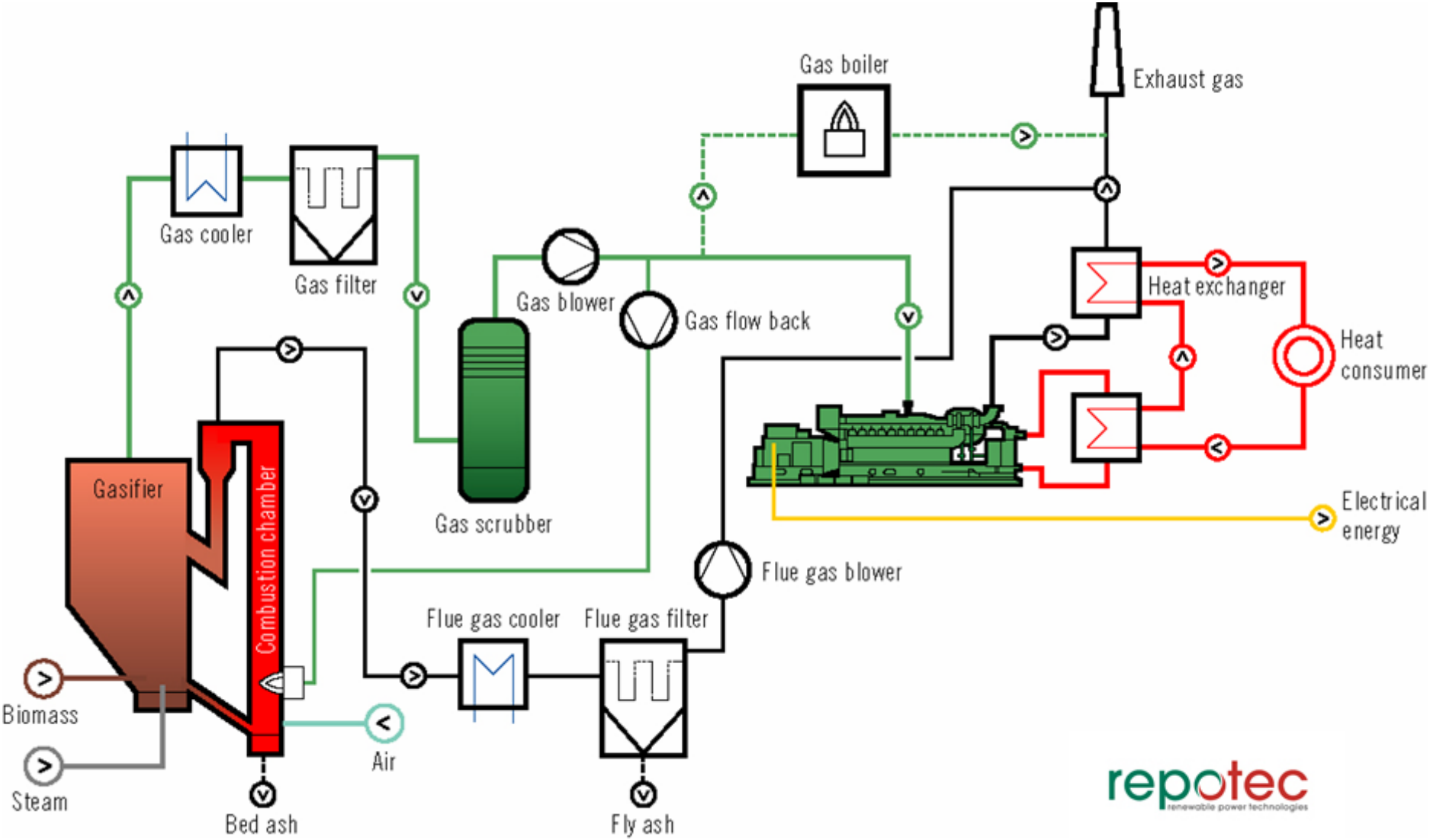
repotec renewable power technologies

Wood chips:	8 MWth input	
Wood gas:	N_2	3 %
	CH_4	10 %
	CO_2	23 %
	H_2	40 %
	CO	24 %
LHV	10.5 MJ/Nm^3	

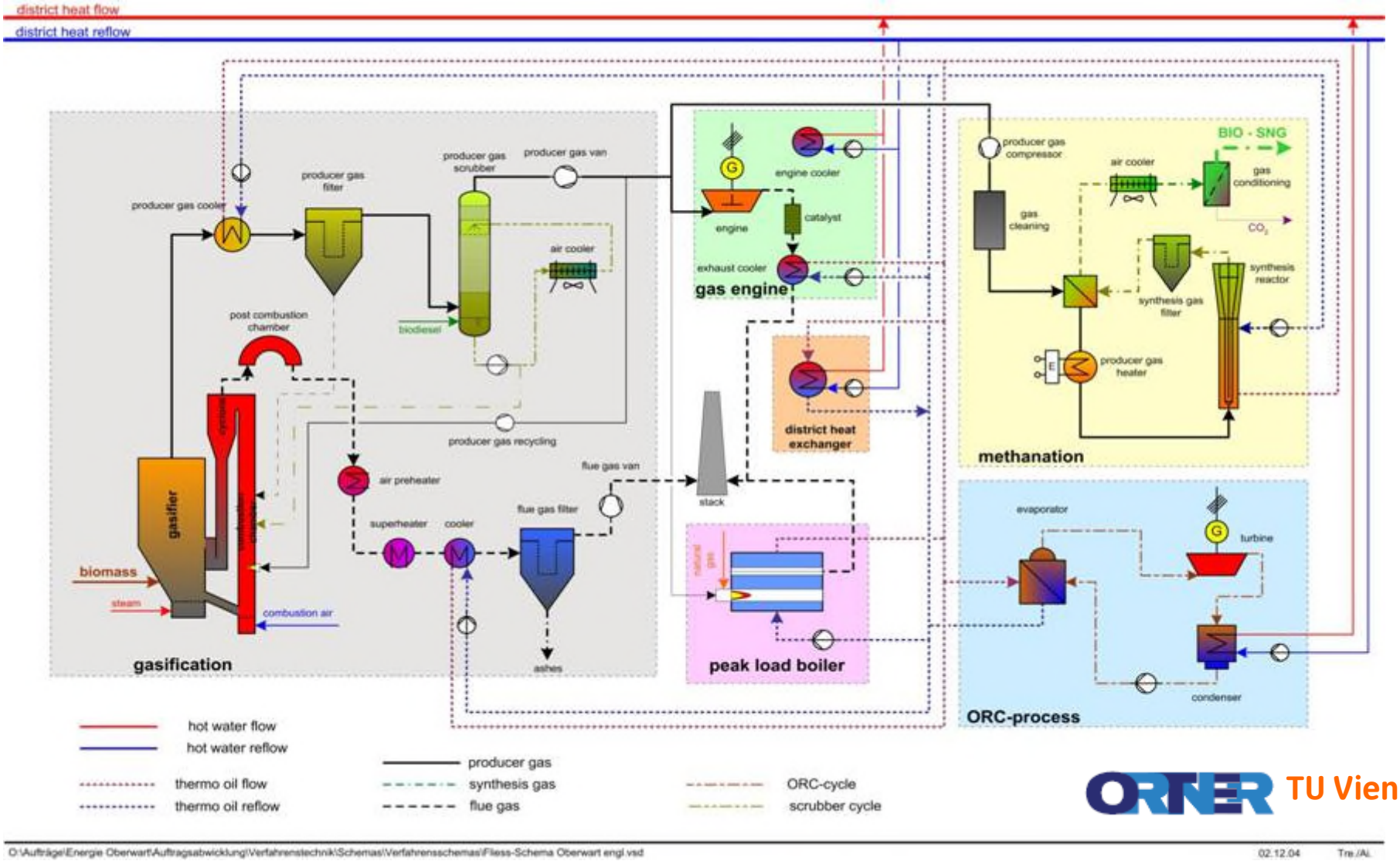
1 x J620
1 x 1.97 MWe

...more than 50,000 ophs (05/2012), ...commissioning 09/2001

Biomass Gasification Güssing/A



Follow up project Oberwart/Austria



Follow up project Oberwart/Austria

ORTNER

fluidized bed steam gasification
Thermal oil circuit + ORC (400kWe)
Wood chip drying

2 x J612
2 x 1.2 MWe

Wood gas:	N_2	3 %
	CH_4	10 %
	CO_2	23 %
	H_2	40 %
	CO	24 %
LHV		~10 MJ/Nm^3

...~10,000 ophs (07/'12); ...commissioning 2007

Follow up project Villach/Austria

2 x J620
2 x 1.97 MWe

fluidized bed steam gasification

Thermal oil circuit + ORC (400kWe)

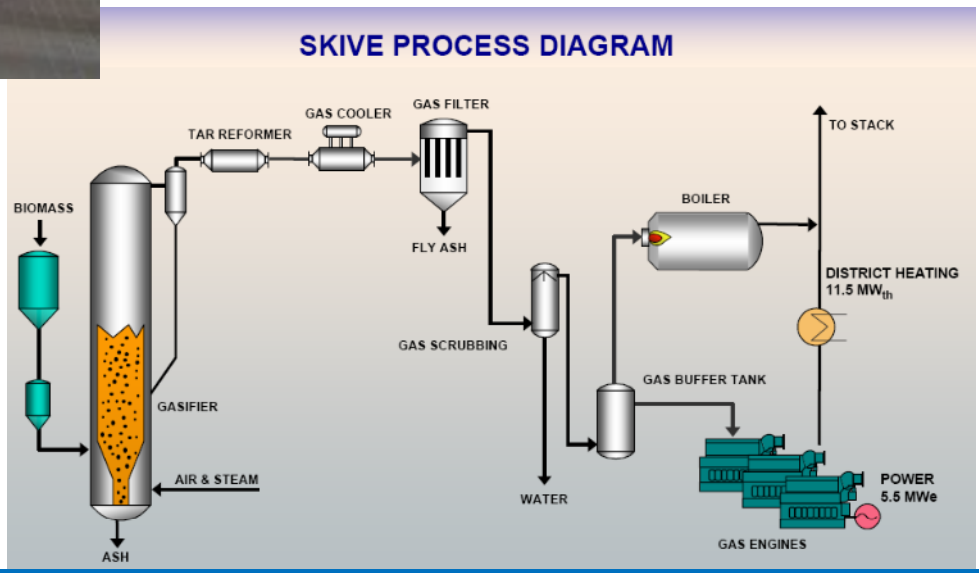
Wood chip drying

Wood gas:	N_2	3 %
	CH_4	10 %
	CO_2	23 %
	H_2	40 %
	CO	24 %
LHV	10.5 MJ/Nm³	

...~5,000 ophs (07/'12); ...commissioning 2010

Woodgas plant Skive/Denmark

3 x J620
3 x 1.97 MWe



... ~30,000 ophs (09/2012), ...commissioning 2008

Woodgas Skive (DEN)

Biomass gasification Molla/Spain

2 x J320 Pel 2 x 765 kWe

Wood chips:	N_2	48 %
	CH_4	6 %
	CO_2	16 %
	H_2	12 %
	CO	15 %
LHV	5 MJ/Nm^3	

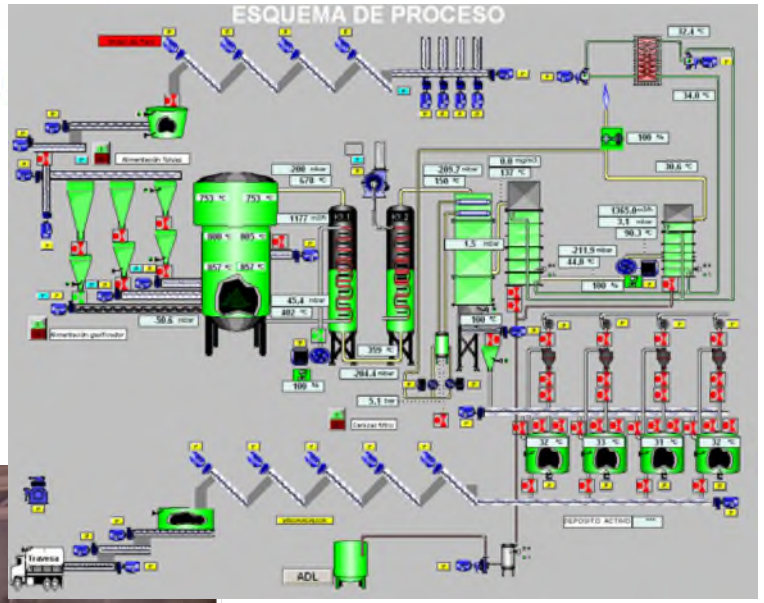
2 x J320

2 x ~825 kWe

... ~10,000 ophs (09/2012), ...commissioning 2010

Biomass Gasification Movialsa/Spain

EQTEC Iberia

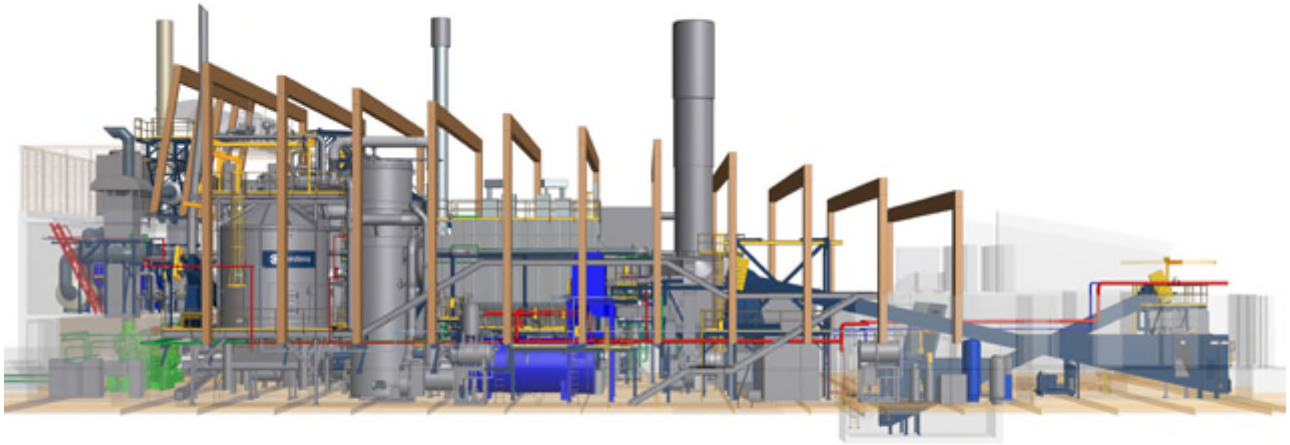


Biomass from olive production

3 x J620
3 x 1.97 MWe

.....commissioning 2010

Biomass Gasification UBC/Canada



Woodchips

1 x J620 1.9 MWe

BIOENERGY RESEARCH & DEMONSTRATION FACILITY (BRDF)

CO	14-15%
H_2	17-18%
CH_4	1-1.2%
CO_2	12-14%
H_2O	6.6%
N_2	rest

...commissioning 10/2012

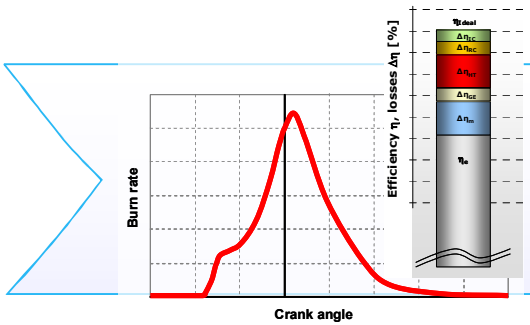
Special gas development

GE imagination at work

Special gas development

50+ years experience

comprehensive data base & analytical methods



conceptual studies

component Test

Single cylinder test

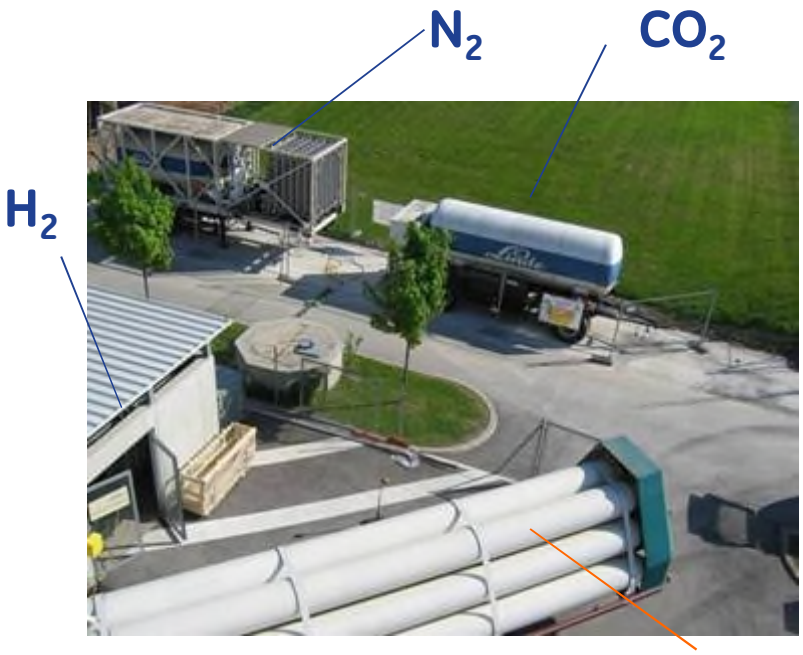
Full engine test

Pilot plant

Special gas product development

Combustion development at single cylinder engine test bench (LEC Graz) with artificial special gases

- Various test runs with different combustion concepts
- Gas type specific concept selection



Synthetic gas mixing plant

Single cylinder test bench

Biomass Gasification Güssing/A

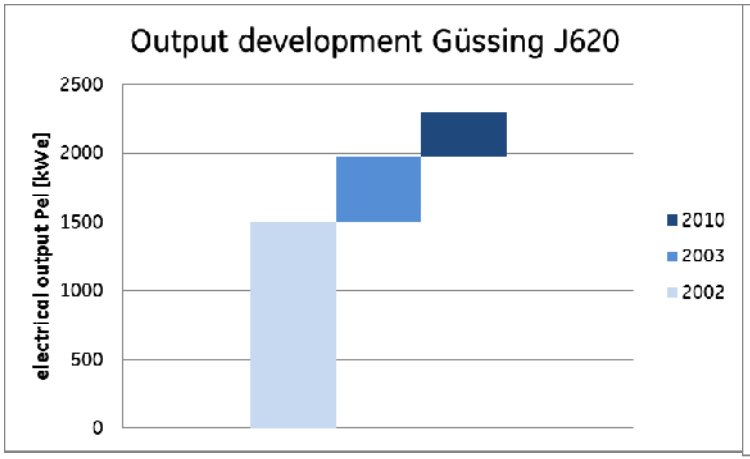
1 x J620E 1.9 MWe

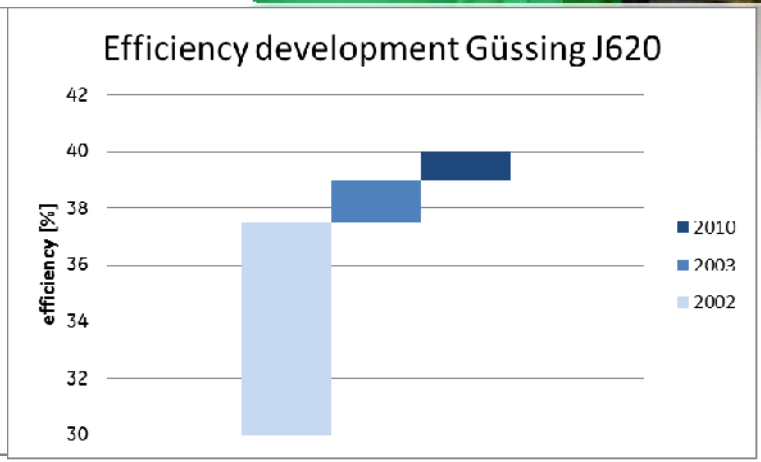
Engine

Upgrade

10/2010

J620F 2.3 MWe





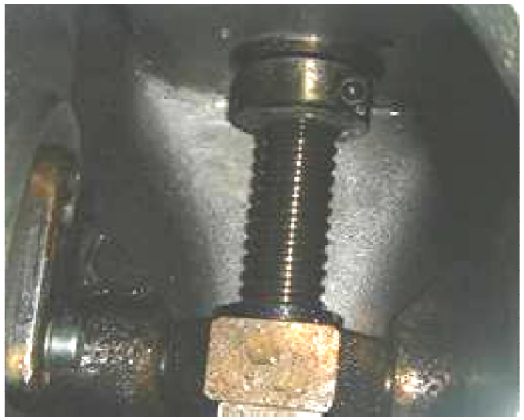
Crucial points in the utilization of wood gas

- Gas cleaning technology

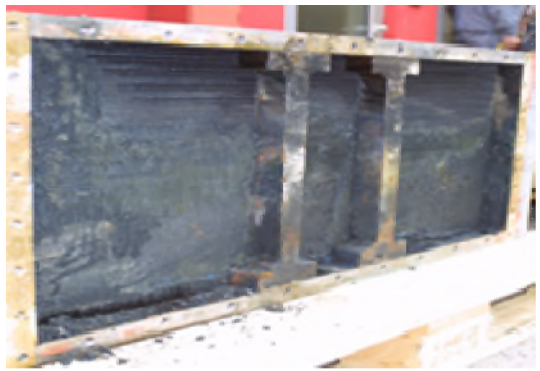
- Fulfillment of emissions

Condensate, deposits (water, tar, naphtalenes.....)

Fuel gas
TI 1000 – 0300



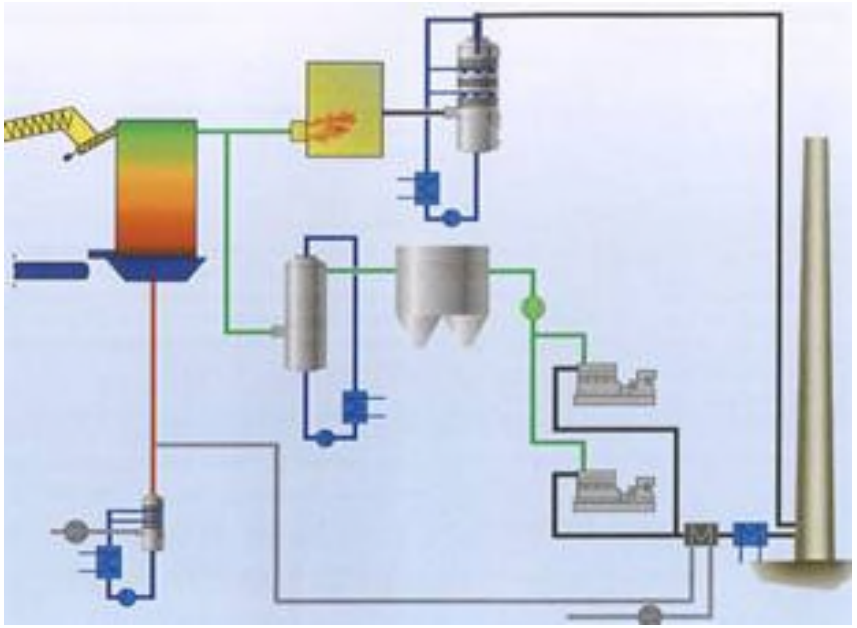


Gas cleaning is the key technology

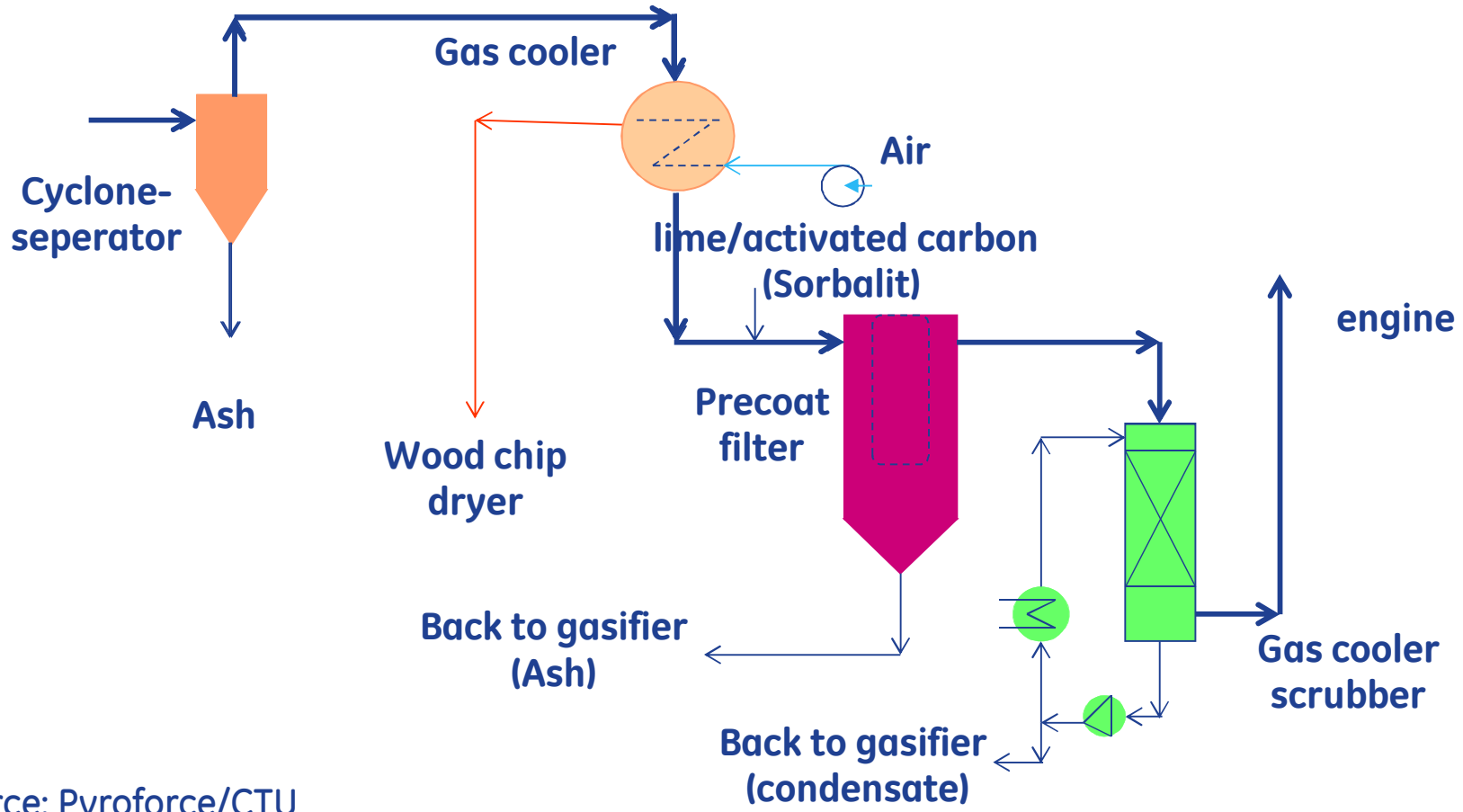
Gas cleaning Harboøre

Wet scrubber & wet electrostatic precipitator



Results: oxidation catalyst ok;
initial and O&M costs high (High disposal/treatment cost for contaminated water)

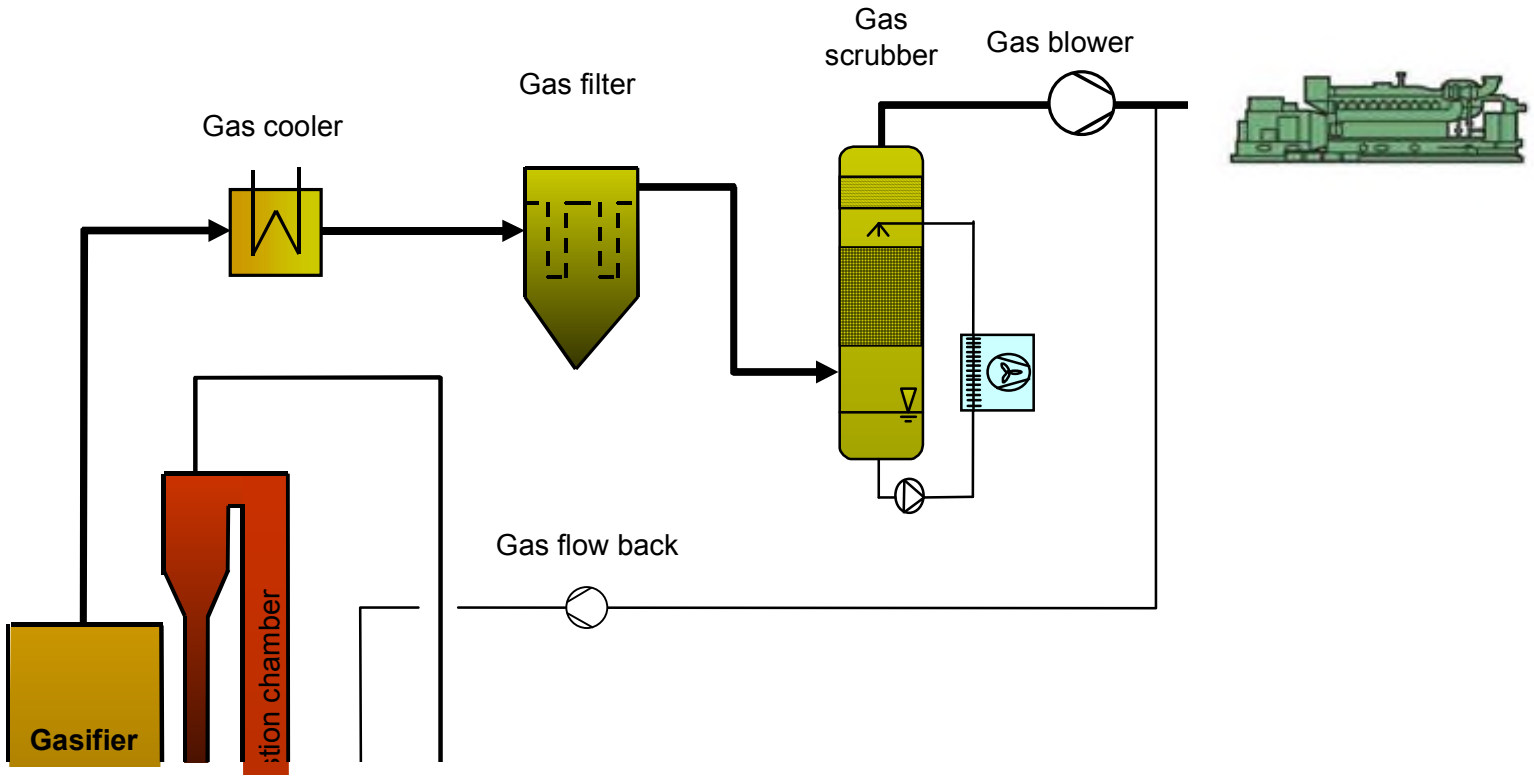
Gas cleaning Pyroforce®/CTU



Source: Pyroforce/CTU

Results: oxidation catalyst ok; relative high H_2S content
relative high NH_3 content
first and O&M cost acceptable

Gas cleaning repotec
Scrubber with RME & precoat filter



Results: oxidation catalyst ok; relative high NH_3 content
first and O&M cost acceptable (RME production on site)

Crucial Points/Technical Barriers

Emissions limits according e.g. “TA Luft”

NOx ≤ 500 mg/Nm³

CO ≤ 650 mg/Nm³

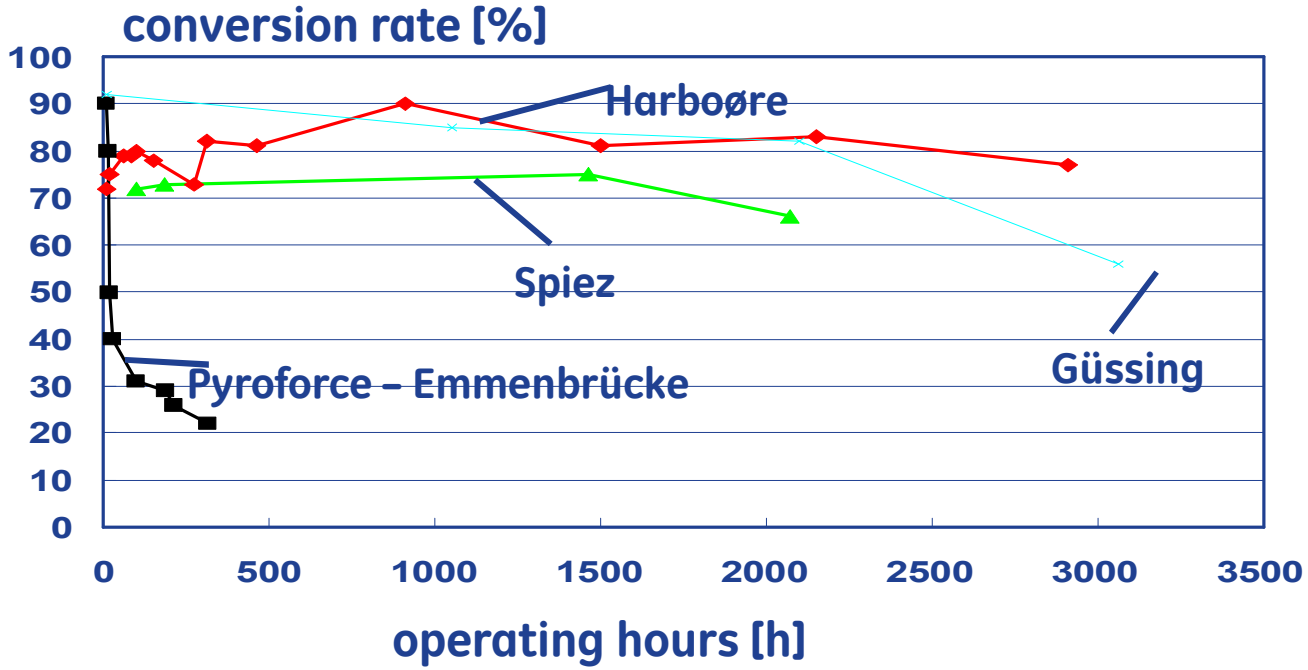
		Gas		Exhaust gas [mg/Nm³]	
Plant	Engine	H2 [%]	CO [%]	NOx	CO
WUT Wamsler	J 208 GS	9 - 12	20 - 26	50 -150	2500 - 3500
Boizenburg	J 612 GS	13 - 15	16 - 20	200 - 250	3000 - 3500
Harboore	J 320 GS	18 - 20	20 - 30	200 - 400	2000 - 3500
Güssing	J 620 GS	30 - 45	20 - 30	450 - 500	3000 - 4500

unburned CO- content of pyrolysis gas

Emissions

unburned CO- content of wood gas requires exhaust gas after-treatment

=> first results of Catalytic reduction promising



Gas cleaning is also here the key technology

Summary

- wide range of H_2 gases can be used in gas engines
- key factor is laminar flame speed
- main technical barriers:
  gas contamination (tar, humidity....)
  VOC/CO- emissions

GE imagination at work